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GOOD MORNING AND AFTERNOON. WE HAVE OUR FOURTH SESSION in the asteroid grant challenge summer series we've had some fantastic cover stations you just had a phenomenal presentation by NASA's SSERVI senior scientist David Morrison sharing with us some of the science behind why this is a grand challenge. I'm excited for this session covers were moving into a conversation around the maker movement. One of the things that David closed with was the fact that the dinosaurs not have a space program. The dinosaurs also did not have a maker movement. In one of the things I'm hoping we can do today is explore some opportunities with this great group of folks about how we might meaningfully engage the energy and ingenuity that we can see popping up all over the world in fact. In order to make this easier on everyone tuning in and I think that everyone on video now is one another. I would like they could be useful for everyone to go around. Will ask for your name your affiliation a couple of sentences or minutes about what you do and what you're passionate about and the question I asked yesterday that stirred the pot Star Trek or Star Wars I think I will stick with that one. That got folks juiced up. With that we don't we start with Stephanie.

) Stephanie M from is a community where of makers together and do stuff together. My passion or might roll in this is maker is the reason why I set up a community is basically I wanted to start a maker movement but I wanted to share that at the same time it's great to eventually could get the key sets and the like. I don't think it's that far away

Don't forget your movie choice.

I will have to get back to you on that.

I will go with Star Wars.

Already some grimaces. Let's move down to the first grimace Alex. I start with Star Trek. Light sabers to magic even for my taste. Yes we can hear you.

Tell us all a bit about yourself.

I am Alex I am from space gambit a space program working with NASA on the asteroid grant challenge. This year we're funding loads of cool asteroid projects from maker spaces and all around the world.

Thank you sir. Let's move to Neisan .

Hello everyone. My name is Neisan I am second use an agency that is aiming to complex challenges through collaboration. I am part of the team that has implemented the national

initiative saw local challenges through different communities and we just had a big event covering 124 events in 13 countries. We are also involved in the maker movement in different ways one of them is we were actually working with the city of New York to develop a program that actually that's a maker movement and actually incubates six projects. I'm very much involved in that work as well. I am a full on Star Wars fan.

Very good. Thank you. Let's go down to James.

Are beginning a battle started already?

Hello everyone. I am totally a Star Wars and sorry Star Trek fan. Freudian slip I am with Alex. The magical elements does not do it for me. I'm a hard science guy and that's what I love about Star Trek. Might they job I'm a product designer so I design things. I've been doing it for a long time now. If there is one truth about inventing or innovating is that the magic happens when you are trying stuff out and when you are feeling. -- Failing. It's a great deal report type is worth 1000 pictures. I believe that honestly that is the only thing that works really the only way to invent something is to prototype and make it as close to my heart. Of course we do that every time we designed a new product we physically make it and put on technology on the table and start building. That's how I have always designed things. The maker movement is something that is an extraordinary phenomenon and I'm interested in helping on the grand challenge but also I have established an open space agency has I believe that it's possible through making and open hardware and open software to start creating is for technology to help support the activities of government programs.

Great. Thank you. Will move to Praveen . Maybe you did not hear the initial question was named affiliation and a couple sentences or minutes about what you do and what your passion is and finally whether it is Star Trek or Star Wars.

Hello everyone I am Praveen I am the founder and CEO. Help makers and innovators get from an idea or a concept or a prototype to scale and market. That is our whole mission statement. To have a really big impact need to be able to get it to market and we sell a lot of needs of failure Seahawk people get past that. Our table customers range from startups in the Bay Area to the large organizations like Boeing in the same problem of how do you get the innovation to market as soon as possible in the most efficient manner. Others range from fuel-cell technology for this sequence. These days technology is so complex and such a diverse range of technology available we help innovators figuring out how to make the right trades that will work in the marketplace that's what we specialize in. Not only do we have and will help people build iterate and the most important we scale that's what we do. I'm deftly a Star Wars and.

Thanks Praveen .

Is James on the line?

Yes I managed to call in

Did you hear the question before everyone?

Can you repeat it please.

Give us your name your affiliation with a passion and couple of minutes about what you do in the passion you bring to this topic and then finally close out with whether you are a Star Wars or Star Trek fan.

My name is James Wong and the reason I have been asked to be here the last few months of my life the last year and a half have been this incredibly oscillating journey. Whenever I am in NASA company I am blown away by the credentials that people have the astrophysicists and astronauts and generally amazing human beings like Mr. Kessler there. I am very different from that. I don't have the background in the hard sciences. I am a software engineer but that is very different from the kind of thing we're doing here. In a year and half ago about a year ago I got the opportunity to participate in NASA's path on that the space X challenge in minute of winning a prize and the rest has been absolute history. It's been this incredible journey in which we won a prize and were asked to submit formal proposal for the project that we created for NASA. In the process of putting together this proposal we realized that the cost of the coming space entrepreneur has dropped so dramatically that it's beginning to look a great deal like the cost drop in semiconductor that led to modern-day Silicon Valley. We have an opportunity to be on the vanguard of something amazing. On a wing and a prayer we decided to become entrepreneurs. We started researching how to create small satellite that help solve some problems that we have here on earth. First we were working on solving the problem of returning rapid images from Earth observation and activated to this idea that we could use tiny in expensive satellites to create closed network and enable the Internet of things in an amusing way. I think the most important lesson we learned was that being an entrepreneur especially in a brand-new field like this is incredibly difficult. It requires deep passion that gets seated when you are very young in order to continue through some of the problems that you need to tackle. And so that is who I am and where I came from. I am definitely a Star Trek fan.

Thank you James. You are an incredible individual.

Thank you.

I am on by your journey.

James you can go and start your WebCam.

While you are starting your WebCam I will turn to Andy who was here with me and aims and I think you know the question.

My name is Andy and I have been a Silicon Valley inventor and entrepreneur in the past 35 years. I have done a lot of commercial industrial military products my latest and biggest project was oral care is a toothbrush and I will demonstrate later if anyone is interested. I actually met through maker fair enjoyment from the chief technologist office and I was showing a 3-D printer to keep said that I was working on. This is fantastic were thinking about doing this. Do you want to come over with starting a thing here called space shot. I said sure I would love to. In that process I actually met another job in a student going for his PhD Z Chester was working on it project called chipsets. These are satellites that are about the size of a week then. The question was how to deploy those and get them so they are in an orientation and spinning properly once deployed from the mothership. As a mentor and partner on that project I actually joined the project and that was the first pick start space project also. It really is at the heart of what maker movement is. It's very exciting. We watched it several months ago. But not all of our mission goals but most of them and were continuing on with the second version.

And Star Wars or Star Trek?

Star Trek the original series.

There are some very happy people on this panel. Star Trek wins out today. I think for those that are tuning in and fellow panelist you can see that we have a fantastic group of folks to dig in and around this question about making. Rather than start way out one point I had was to explore what a maker movement is one of the things I have found time and again within NASA is that even though NASA is made up people that are makers at their heart there is an unfamiliarity with what the maker movement is. I'm not sure that is viable. Article on the expertise in this group and start at the broad question of why is the maker movement important? You are all very active and contributing in it. I think that is probably a more important question to lay the foundation as we look to build upon that going forward. Particularly in the context of the grand challenge. I will work backwards and throw this out to Andy to get started and then as ideas pop I hope this is an open conversation where you feel free to jump in.

It is interesting the maker movement actually started with punk rock. All of the things that hunk rock people were doing, body modifications: modifications Vehicle modifications, make your own stuff. They actually produced a movie called make or die that is at the heart cousin a lot of the things that are required to do space entrepreneurship don't exist today. They have to be invented. And you have to big steel and borrow. It is a very interesting place and time to be in space and low Earth orbit in deep space and looking for asteroids. Those things don't exist. And that requires a synthesis or that

Genesis of things that people have not thought of before.

Other thoughts? James Wonka jumped right in and started a company from the have done and other thoughts on the importance here and touched a nerve with you.

It really did. I often tell the origin story when people ask me this question I grew up early in Nairobi Kenya. I tried mostly middle-class in Kenyan family. My parents were professors but even for a middle-class family in Kenya in the 80s we typically didn't have a lot of manufactured entertainment for children. As a two television channels and it was not really a Toys "R" Us I'm sure you get to one if you wanted to but for the most part it totally want to do something they had to entertain themselves. They had to build their own toys. Was a dump for old cars not too far from my childhood home. Me and my friends would break into the stump and still parts from these cars and build little tiny toys. It's something that was inherent part of my childhood and it wasn't until we got to the United States that I understand the significance of creating. What creating his and what making his is affecting change. What's really important about that word change is that nothing is ever as good as it could be the story that I love the most about America's best moments of change is the story of the building of the Apollo program. When the president -- when Kennedy announced that we were going to go to the moon this huge of young people flooded to the Mojave Desert to build the Saturn V rockets in the Apollo lander's and they didn't with no guarantee that this was going to work. It was institutional change because it was guided by NASA but the movement the feeling the idea that we could make some thing to completely change the vector of history trajectories of history is powerful. When I showed up to that happened on first I did not think much of it in by the end of that 48 hours I felt this compulsion that I never had before. Aching is important not because it creates the making is important because it almost is a form of spirituality but maybe a little grandiloquent but it is powerful. It satisfies this deep-seated need that humans have changed things that are not the way they want them to be. As an adult it is the closest thing I have found to religion. I love making and creating. It allows me to affect my world and is a power that cannot be taken away from you no matter what. That's why I think is important.

Is going to build on that. I love this idea that at some level we as human beings are all makers this is what makes us different and special and I think makers have this hardwired in their DNA in the understand experiencing to make tools is a pathway to some aspect of what it is to be human. I think it's a well-made point and I was going to reflect on the fact that all great innovations and I love the story of the space program but if you go back to von Brown these were makers. The space program itself started with makers and they were makers in the purest sense. Funded extract inventors going out with a vision and trying to make it happen just for the joy of trying to manifest something I think what is true is very hard for a big organization to truly be disruptive because I don't do those iterations in the experimentation or cross pollinate in a way which makers do easily. I will still Alex's example that he often uses of brothers to bicycle makers to invent Howard flight were the world's industrial complex could not because they involve technology of bicycle making to making a strong but light structures. Makers have always been there at the beginning of any resolution. They are an important part and to answer your question

of why we need them because they acyclic are the source of disruption.

I completely agree makers have always been there I will take you further back beyond those technical age and way back to create the tools very first tools I believe that must've been rubbing sticks together and having a go at the things in unusual ways. I think that generally what a maker is really just taking whatever is in their environment whether it's available and make something new out of it. I think what really turns makers for what the maker movement is about is sparked by tools. It's sparked by more tools and more availability of hardware and open software that supports creating -- creation of new technology. I think that is what made a movement as opposed to individual makers over the years making different things. I think this is the perfect time to that but also for me the importance of the maker movement or of makers generally speaking is diversity is that there is a diverse range of people putting together completely imaginative

We all use the results of what makers have done every day. I am encouraged right now only because I can get cheap flights thanks to the right brothers. How many of us using Apple products? I know I am right now

Anyone else?

How many of us are using Apple products?

Yes the home home computer club. These were a couple of college dropouts who went to a hacker space and within that is a hacker space. The legacy is why we are here now

But the interesting perspective if you look at the maker movement has been around since the beginning of time. 100 years ago there were a lot of makers and a lot of new things that have come up with what we've gotten really good at in the last say 50 years is scaling. The reason you are able to get the maker movement and not just because of the right brothers but also the fact that we got really good at scaling and making it accessible to a lot of people. So to have a real impact the maker movement than it needs to transition to the next phase and be good at scaling. But all that has happened is the were so focused on scaling and turning things into commodities we forgot a little bit of the fact that a single person can still have a large impact. We can still enable a single person to scale by himself without having to stifle his initial vision. In the interesting thing right now appointed time we are at technology has never been more accessible. 30 years ago if you wanted to get access to a high-technology components it was almost impossible. These days technology is not the barrier. Testability is not the barrier. We are also at a point where scaling is not a barrier anymore. Great things are possible now but the challenge is different in the sense that how can we make these leaps without losing our way along the way. Just because of how accessible everything is. It's like going to a hotel with a lot of options on the food table and we somehow forget to enjoy each one. We just get busy at trying everything. Versus something is placed in front of you and then you really appreciated. You can really spend a half-hour eating just a small dish. Those are the two

end of the spectrum and that's true for technology as well. That is the challenge of the space going forward.

I think there is another aspect to this is another dimension to your question and that is in the last 50 years in set aside the patent and the idea of what idea one big idea if we look at the right brothers again there are a number of ideas that happened simultaneously that allowed that step change. Was the construction and shape of the wing which was actually open software. People knew the wing shape already. That was open source. If the distribution medium, ethylene, power to weight ratio of the combustion engines, new forms of capital outfitter Graham Bell was the BC behind the right brothers. In all these innovation happenings some ultimately that allowed powered flight to happen here I think what is amazing about makers is because they have a hacker spirit they hack in a spirit of collegiate miss and openness. You can actually get a number of innovations happening simultaneously that can pop and allow something to get to the next level of maturity. And that is what happened with the Apple II innovation and hardware in silken chips software manufacturing lots of things happening at the same time that allowed this thing to come into existence. And so this is when you get a step change. Makers are not just the engine of the one idea that the engine room of these shifts these big changes. The opportunity is for us to get good at understanding how to harness makers so that we are collectively in the best collegiate energy happening in a way that we can actually deliberately top 10 innovations at the same time and ship something and do something really special. And that is the other spin to this which makes the makers like a hugely exciting phenomena

From our perspective a doing a lot of thinking around where does it current maker movement stand. We've seen that were actually moving from a world of mass production to one of production by the masses. The hobbyist can mass-produce and we've actually in thinking a lot about what the definition of maker currently is. Understanding that there is a whole history of what makers in the current paradigm. We've been defining that as someone who has an original idea and what is so interesting of what's happening out is that we seem to be in the early stage of a big movement the democratization of all of these new tools where there is actually an industry built around it. Private sector players now and a way to approach making is around exploring the system and understanding everything around that and modifying and we see affecting so many spaces like in the whole movement around drones and imaging and you name it. Even just small solutions that help at the very local level. And so there does seem to be something different about it this time which is a new capability and new technologies and very much a movement that is about sharing and really. Collaboration as well. You can add to the whole movement around maker spaces the whole approach to building things.

Another effect that has happened is what I call the trivialization of manifestation. A lot of people have hit on that but what it is it because there is so much open-source freeware things that are in the digital domain that allow you to take your idea whether it's a circuit, software, 3-D design and these tools are very powerful. When I first started in engineering at seat of a decent mechanical engineering program would be \$10,000 per year those are now free downloads. Circuit design free downloads. To make the boards, -- when we made chip satellites and send them out to a supplier they were eight dollars. We

got them back in a week. To get those have now gone to trivial. We staff to make circuit boards. We don't have to make circuit boards. We don't have to spend a fortune. We don't have to raise a lot of capital just to do this design work that design and conceptualization has been very powerfully in the digital domain whether we are doing digital signal processing, circuits design all of those in getting the software is trivial. It is not a barrier for an individual or corporation that used to be months or years of a company's dream was to get the software. And then to learn it. To have that and to manifest an idea and actually sit down I have been in many meetings where people just there's no paper they open a laptop we all discuss them in a digital domain doing everything and then the next meeting we have a physical thing that we are putting on the table. Here is the housing here is a circuit board. By the way I have the software. The fact that a supercomputer is in your pocket. You have a smart phone that is an incredibly untapped resource of computing power. It's almost free. It's an unbelievable age that enables people to make things and to realize things were before they had barriers.

That is a really profound point. I want to say that an interesting anecdote from our adventures in the lab we come up with this idea for an cube set whether how the world would build in real as we would have a competitive advantage over larger satellites if we built something cheap but that still had compulsion. We researched propulsion methods to figure out exactly how we were going to keep this thing in orbit. We ran across something called the vacuum thruster which is a type of plasma thruster that was researched by a professor at the University of Washington Bible and forget exactly whether research was done. And we were cool so maker fair was coming up in a couple of weeks and wouldn't it be awesome if we could 3-D print a vacuum thruster. We all met at a comparable shop in the village in Manhattan and started talking about what we needed to design and 3-D print it. One of the members of their team goes I know we only have a week and a half but do you think we could build one? I turned them and said that is ridiculous. We cannot build an ion thruster in a few days. And in fact the rest of the team and said well maybe we can. We went online and sure enough the part to build a fairly effective ion thruster are mostly available on Amazon. We ordered these things got all of our parts did not sleep for a week and half and build this working ion thruster and vacuum chamber and displayed at maker fair. The idea was that the in order to create stuff like that have commoditized is so powerful and the reason I say that is to bring up the second part of my story which is one of the stories of American industry that I really love is the story of how container shipping changed the world. This really simple idea that if you could fit lots of things really inexpensively into a box and send them anywhere around Earth. It would drop the cost of shipping down to effectively zero. And people thought the biggest effect that would have would be on the bottom line of the shipping company. It is not what happens. What happened is all of a sudden as a consequence was being able to produce goods and move them to another place for nearly nothing economies spun off all over. It's the reason that China is a global power right now is the reason that cannot is seeing a resurgence because of the incredible amount of commerce that now travels through the Panama Canal. It has affected the global economy more than just about anything is a very simple idea that shipping should be dropped to nearly nothing. The point that was just made tools that we are now using to become makers the software the printers that we are using to prototype the cost of creating rigid circuit board have

dropped to the point where they are approaching zero. And we cannot even fathom the consequences that that will have we think is owing to make it cheaper to be an occupant or is going to launch 1000 ships. I love that point

Even using the model of 3-D printing what happens there is that every other week now a new 3-D printer is being introduced on the market. Just because they can.

I think not even the cost or actual access to the tools it's very much on the platforms they are being built to support makers. Right now there's a system where you can have an idea and goes into a platform like quirky were someone else in the community actually approves of the concept they may actually go and build it for you with the whole infrastructure on the backend or you could actually be a person that prototypes or that has some sort of a real spirit and actually either go to a crowdfunding platform or get support to care for that campaign or are the backend of the manufacturing side of things. There are tons of opportunities in this and this place for example in manufacturing really connecting communities and really sharing concepts we keep hearing this concept of cohabitation in the maker space. Really mean it's coming together to really share insights and projects and ways they can manufacture things at scale. Lots of potential in things like that that are just -- the Access to tools is extremely relevant but there's a whole anchor system that spots from it as well that we are seeing.

The question to dig in on this a little bit. We are seeing an opportunity where tools and access is no longer the issue. Are their thoughts on how we might be able to coalesce people to work on massive problems so that they don't go and get a 3-D printer and print out a bunch of plastic widgets at then end up in a landfill rather -- is there a sense or thought on how do you coalesce this energy that now has incredible axis to start doing stuff is collectively really meaningful? One of the things I look to as exciting about the movement is there are collective groups and that it is about sharing but a sense on how do we -- it is somewhat tied to the grand challenge because as a massive global problem. How do we start to set this together? Who has thoughts on this? Smack

Makers are already committing to problems space gambit is funding asteroid threat detection which relates to the grand challenge but also things like which is the open source [Inaudible - static]

The \$50 prosthetic limb you can download it from and print it yourself. In Japan as well open source is used to mass the radiation leak at Fukushima. This type is being done. It's not really out there in a big way it but it's being done and I think talking to people who are doing it would be a good way to figure how to do it more.

I think with there's quite a lot of places where people could gather physically or virtually I think that it's a really good question has a lot of the times we kind of people gather at 1011 and then with no follow-up from their own. I think the challenge really is to provide people I think a sustainable kind of grouping that they can a means of collaborating

together and not just -- most the time people come to a train 11 they travel from wherever they will make a group there and then work together and make something. But after they would be perhaps going back into a different country or a different town and that makes continuing to work on that kind of project harder. But of course there are the maker spaces which obviously have more local people. I think part of it is to work up how to provide a sustainable platform for collaborations whether it's online or off-line kind of almost bridging between you would want people to come all the way to work on hack-a-thon for example to keep going on it and if you want to do that you want to provide the means for them to keep talking and exchanging ideas. It's harder when it involves hardware and and had to get that duplicate all over the place if there's some kind of physical barrier still.

I think something that the question is how do you get people to move from makers to entrepreneurs from holding widgets to building spaceships. One of the best things you can do is add the establishment. The CB -- you do what you can to make sure that one or two prominent entrepreneurs close. One of the most inspiring things happening right now is the success that Elon musk and space X are meeting with. Elon musk is someone who comes from the startup community and build this incredible awe-inspiring company is the closest thing the modern age has to Howard Hughes. Most of us will do something that big but the power that has on people to realize that the thing they are doing has incredible amount of relevance to a huge mission to humanity is what is going to create that change. I had a moment like this. I recently had a chance to hang out with an employee from space X I'm a software engineer and never occurred to me that there's anything I can do for space X. He was telling me that one of the jobs of the year hiring for the most people who can take the massive amounts of data these rockets collective and dissent to the atmosphere and make sense of them and perform analysis on them so that they can understand how to build a better rocket the next time around. Data analysis is something that Silicon Valley startup committee has been doing for a decade now incredibly well. Or it's getting better and better. Companies like Facebook and LinkedIn are built on this idea of the analysis. Seeing that you can take these skills and apply them to a huge problem that is being solved by someone who started as a maker's entrepreneur is one of the most powerful things that you will do. That is something that gets people out of their seat and says okay this robot idols is cool and I think I would like to go to Mars now.

I think that it is on a very important point on so how do you build startups in real entrepreneurs out of the movement? That is going to be a big metric on this. We've started to see some better interest or bigger interest in the space. For example things that we've seen the acquisition of that for example by Google. Where some actual big companies are being extremely opportunities. But the reality that as a community level in the maker level there is still a lot of need and there is still not enough investor interest for example or enough spaces. We are seeing offers of challenges as people are running into and it could be very expensive relocate inner-city actually getting to the right place in their nearby community. There are many specific things that can be done around this. We've seen interesting things in terms of trends. We have met with city investors that were backing hardware projects actually requesting their projects to do a crowdfunding campaign. Crowdfunding now as of May become a validation by the market. In there are

things like this that are still very much developing and were in the early stages to show that their organizations and people trying to break through those barriers.

One of the important points when we get at these big goals in the collaboration site is a combination of three different things that need to come together. One is a group of people who think about the possible and pull people who think about the art of the possible are willing to push the boundaries. But along with them you need another group of people who know about all of the failures in that same row we've been there who have failed in those two groups usually do not work side-by-side but when you look at any great team and even if use the space X example is a team of people to the combination of the two groups of people are three groups of people. What is the people for thinking about what is possible the other team is a team that is battle hardened and has tried many things and knows what will not work and the third one is the driver. The driver it could be the A could be the motivating force it could be the person who brings the team together. If you apply that to the space X team and quite literally less than 5 miles from space X talk about and a fair bit. It's a combination of those three things. A lot falls into that driver part. He is one who brings that in questions the norm. And smashes those two teams of people that don't want to work together into the push them together and forces them to come together. You're talking about a platform I think that's one of the challenges that we have is how do we get the maker movement and full of people who believe in pushing boundaries with the other group of people that has tried a number of things and has failed and knows what will not work had we bring those two together and then drive them forward it is an interesting way to look at.

I think the pattern of doing that exist in a very obvious way else talk about whether or not we're second bubble the second.com bowl. We are but the reason that it's not Rangers as before his all these patterns were being discovered in the late 90s. People were doing that they were poking at the fire to find out what the hardest part was in most of them got burned. In this newest boom many people who got burned before and many investors came back. Many entrepreneurs came back and instead attacked the problem with design patterns that have consulted the first time around or at least have discovered the first time around. Right now as space entrepreneurs we have very few patterns. Very. Few patterns. There's lots of people thinking about stuff but actually creating things is still really difficult. But they are starting to show up. Space X is a great success. When once recently had uncertain not plain labs I forget. Skybox. Then once the time a six early dollar contract with Apple these are the people with the Vanguard of the problem-solving mission that needs to happen in order for this to turn into a boom. Those of us trying should be taking notes because there will be a crash before there is a boom. Everything we are doing now will fall apart little bit before we get to build stronger. That is a really great point that you make about taking these two groups of people and smashing them together right now. Most of us are still being experienced or is but there's a small group of people who are beginning to be the champions of people who solve these problems.

Is a great point you make of the bust is coming I think we all need to have the fortitude to work through that bust but after the bust is then really impactful. We love the boom defined as or the bust the finest in the third phase is where the real magic happens in

the.com bubble is a fantastic example

Think it's interesting I'm trying to get back to Jason's original question I think it was were in the UK and trying to replicate the tech boom as best we can. I think it's interesting we start thinking about or connecting those concepts that making and entrepreneurship and exit are somehow intrinsically linked. If you go if you ask someone in the corporate pay what does maker mean to you and they will say is that mean we can get people to advance for us for free? Of course that is not remote motivation of makers and all. Maker wants to invest because they want to spend time with her colleagues and get that sense of work together to crack a knot. The core of the motive. I think it's worthwhile teasing out this idea that motivation and linked to exit or the Grinch or especially when it comes to space entrepreneurship because exit the plane once for example or exit are probably going to be slim. What space entrepreneurship is going to be driven by passion and just that sense of being part of something bigger. A lot of it is worthwhile in that for a little bit just disagree with me but I wanted to get some sort of worthwhile observation

I think one of the things is to first of all identify what a working unit would be that can do something like the grand challenge. One of the things that has always been critical to a small organization or a large organization are concepts like Kaufman three skill sets in other words everyone is not an accountant or an engineer everyone is not bringing in funds but you do need those skill sets people can wear multiple hats. But typically a person cannot wear 10 or 15 hats. You need people with complementary skill sets. Even if there is collaboration even if it's not an LLC or corporation but within that collaboration there has to be peers in the same area that there has to also be the interdisciplinary to make it work. If people are getting paid or outside resources are required where they get paid then where do those funds come from? What is the burn rate? These are all boring things that people start rolling their eyes at but six months or one year later the effort falls apart. Even if you are queued up and ready now you are going to win the grand challenge money you are going to win the top prize round you get to the point where you win that? Is everyone eating peanut butter sandwiches? Do you do a kick starter? There's a lot of different things but the problem is that you need people with the skill set that can actually implement those things. And even in terms of a collaboration it's how do you define a collaborative team and part of it is that people people's feelings get hurt easily and that is very demotivating. It's something that we have to really work with. One of the things and even the thing that the grand challenge is a behavioral modifier. Ultimately when you look at it it's why are you doing this? There is a goal. I am going to do whatever it takes to get to the goal. It is behavior modification how do teams come together? There are two different tracks. One is the purely competition. Also the grand challenge is a competition. There's multiple teams that are competing in some teams are going to have a set of ideas and other teams are going to have a different set of ideas. They may overlap but who gets their? These are all factors that come in educational institutions have looked at this. Harvard Medical School got rid of grades for this. Reason it used to be that you are all doctors and you are all in a specialty and you are all fighting amongst each other and you have a secretive diagnosis of disease and you are not sharing it with anyone else. When you go into your profession you are then expected to collaborate but you were not trained that way. So you don't the consequence people die. What they realized is that by having

more emphasis on collaboration and then competition. But again these are all decisions. Everyone on the grand challenge could decide to collaborate. That could be a decision. But what is the behavior modifier that is going to enable the community to do that? Looking at things like 3-D printing, the popular 3-D printing happened because there was a thing called Arduino. They basically said here it is. If you buy the boards from us we will be happy to give you software and support in the rebel board for 3-D printers all of those things happened. It was amazing. It was probably hundreds of millions of dollars if not all years of dollars worth of IT that was thrown at a marketplace that enable things to happen. Ultimately here how people interact and how they collaborate or compete is going to determine who gets their.

I completely agree with the environment aspect of it. I think part of it as you were saying is there could be competition for there could be people worried about my first idea but I think that environmental behavioral change is almost encourage people to share and believe in the fact that if you share the idea something bigger will come back and we found it's a it's a good idea you have a good idea and you tell somebody else you'll be stolen. That kind of behavior can be really useful to have. Think generally speaking we can make movement it's just about empowering people and letting them try different things and perhaps just take ideas or word without much limitation and is given a good go and see what happens to it. As opposed to thinking too much about this idea is going to would make money will I do? Dissociate things from that kind of aspect could be useful for inspiration. Almost like a playground or of the allowed makers to explore ideas that restriction would probably be a useful changing the behavior on sharing

That's what behavior is all about. That's the thing about the grand challenges the fact that you are throwing a big goal out there is very clear and cannot be met by a single person. But the thing that we don't talk about very often is the success part. This assessment has to be clean yes or no black or white type of metric that the whole group that forces the whole group to come together and work towards it with a clear understanding of what is the best way. I have seen some really successful ones for example the grand challenge of the early 2000's where we had a robot cross the desert. It was a fantastic clean success factor was there. A lot of teams came together and even now 15 years later the West possible because 15 years. The percolation of the technology in many to make sure that Fred is called out so that we can inspire the next generation of people to say the last one result in lasting changes over 15 years. And for the next 20 years. We also need to celebrate the success and the impact on these grand challenges once the grand challenge itself is met. I think that's will get more people involved.

To that point my friend who is a likes to say that survival is its own reward. That ultimately is the greatest sign of success when we can cross this problem off of our list of global skill problems. I am wondering thoughts about -- the cause is a very grand statement as you point out it's more than any single government agency can do on its own. Thoughts about how to break down such a massive problem in ways that are tangible for people so that we can build requirements and success criteria that we can then give credit and enable people to feel the success and contribute at the same time and potentially play into this idea of a massively skilled community that is collaborating

across boundaries. That seems to be something that we really need big about. I'm curious what the group's thoughts are on this decomposing of a problem in a way that makes it accessible

One way is a little bit like a kickstart or activity. The levels of prizes and just as a participant -- if you are participant and you have a contribution there's a certain level of award. Whether that is an acknowledgment or a plaque or a 3-D printed asteroid or just when you look at a kickstart or you see that but also the larger thing is to try to create communities. If you have a community of people that are looking at the problem -- one of the interesting things about kickstarter is that people who we found our lead programmer he was a contributor. [Laughter]

By having awareness and also allows you to explain the problem in more detail. When you talk about asteroids and people are there a you are telling me these asteroids are really bad. What town in recorded history was ever destroyed by an asteroid makes and people like I cannot tell you a town. But we can tell you that any second and third century there were writings about an event that was probably an asteroid. The Romans could not see the shadows of their shields on the ground. It snowed in China. All summer long. There was no volcanic activity felt so it was probably attributable to an asteroid or commentary impact. There were things that happened three documented cases of people that were hit by meteoroids. One was hit in the hands in the UK last year. There was a lady in Alabama that was hit and a girl's car was struck. We see some tangible evidence but again getting this information out to people -- I always tell people why do you think space is cool? How many miles did you travel yesterday Rex i don't know 32 i don't know 3233 miles. How about 1.6 million miles? We're on this big spaceship called Earth with 1.6 million miles yesterday. We normally don't think about that. Educating people to those facts all of a sudden it's like yes there is something there.

Something I would say we have seen very much that hardware is hard. Even though we have all these new axis resources and tools it is still a hard endeavor and it's not -- we keep hearing the analogy of what is happened with software and how software is hardware is different. It is resource intensive and it means different levels of backup. In a business plan for the manufacturing aspects of it. I think looking at how the local context can contribute and how we can leverage key technologies. For table was mentioned it contribute massively to prototyping efforts in getting communities to join in different prototyping projects. We are seeing different ones. Examples of projects coming up NASA has cleverly a little bit. It's pretty little modules to that do not connect easily. And that lowers the barrier in ways for someone who was the prototype something and explore the concept. There is another company in San Francisco offering system for drones. Someone to do something on a drone actually has now the capability to access much more easily. I also get the sense that those platforms aspects are going to be important in pushing the level of

I'm really glad brought up. One thing I love most about in the interactions I've had with you is how you drive home this point of the grand challenge. The grand challenge is so

important. It's important because everyone here is described the difficulty of explaining or knows the difficulty of explaining to someone why something small they are working on is important is difficult to tell someone why it's important to build a better asteroid observatory. It is difficult to tell someone what is important to build a better operating system or drones. They don't understand how that affects the trajectory of humanity. And it does. It's a call but it's a cog in a very weak sheet. With the grand challenge does things like the lunar X prize do things like you long mosques insane but beautiful time that he is going to put humans on Mars by 2026. Wonderful things about those claims is that they have this really powerful trickle-down effect. I hit the children for a when I can help it but I might have to do it. This amazing ability for lofty claims to affect people who do not realize that their ideas are a piece of a much larger machine. Is incredibly important. I think that is how you begin to motivate people to break down things they know and defined place for the things they know in the cog of a much much bigger movement. The people around me and not in science are beginning to hear about the asteroid grant. Elon musk is getting to be a household name I saw people that I had no idea had interest in science post about skyboxes exit to Google. These are people who have lofty goals incredibly lofty goals. They were so powerful that when they hit their threshold they hit their inflection point and cannot help but trickle-down to the rest of us NASA's most important role right now is cheap science advocate for this country for the rest of the world. When you say things like we won't -- I love telling people that you guys are trying to grab an asteroid and return it to the orbit. That is the best conversation to get you in a bar. It affects people in a really powerful way. I think setting those goals is incredibly important.

We touched upon his important component of the inspiration parts. The other important component also that needs to happen for success is the competitive element how do we channel that competitive spirit? Making sure that all of these teams or groups of people around the world who are working towards this have constant measuring yardstick. If that means we need to bring all of them to the same place at some point in time to see how they compare that they not only are they comparing themselves we also get a chance to talk to each other about their failures in their successes. And then they go back and try again and guess what I hear later it is again that same do or die succeed or fail. That has to happen for progress. The grand challenge need to provide the platform where people can not only get together and collaborate but also get together and measure each other and walk away knowing whether they have succeeded or failed and by how much. Without that this is the second part of your motivator is a competitive element.

Yes that is absolutely true. You have to know your vector

At some point competitors become collaborators because in the early days there was when Curtis in the right brothers. They hit each other. Curtis borrowed some of the rights concepts in making the plane fly. But when the FAA started when you want it pilots license it was issued by the right brothers the first pilot's license was issued to Glenn Curtis eventually you hear about the Curtis right engine. Eventually those company had engine technologies and they eventually merged together. It's inevitable that they are competitors but the technology has to come together at some point.

I think I want to add a slightly axillary point. I think the fact that makers are not a group of organizations and very huge diverse has to be recognized. Trying to turn a bunch of distributors decentralized makers into an organization it probably is going against the natural flow of the groups themselves. Coming from a software background I am almost inclined to say why don't we just encourage people to build different bits of this massive structure is almost different Lego parts. Everyone builds a very small part of it and you don't need to know what everyone else is building you don't need a massive well-defined problem in sick the standard between people. It is to building blocks to be built by different people with different kinds of backgrounds once you have enough of these Lego blocks it's like the toybox. You don't necessarily need to use every single like a piece to build your final architecture. You only need some of them and some of them could be used for something else. Think I almost want to say that lets go of the control and further problems out there and just go there are many ways to do these different bits of stuff. Go and try to build one part of it. Don't attempt all of it in one go because the concept is a part of trial and error are important. And then once there's a significant amount of field blocks lying around it would then be like you were saying the word then you can start taking these Lego blocks and build next level up. But in a much more natural way as opposed to trying to do it coordinate anything upfront and that is blocks happen.

I like that. It's what Google with it building blocks. Piece by piece and modular thing. It seems to be a could be a good way to do it.

I have a question for the group. I think it's clear that something amazing is happening is fascinating and hugely enjoyable the last quarter of an hour. I was wondering where is it heading? Collectively what do we believe it's pointing towards? Is there something bigger?

Yes I love this question. There is ultimately we are trying to get off of this rock. For those of us that don't we want to make life on this rock that are. Those are the two goals of humanity. We hopped out of kids up and trying to get away from where we started and trying to make life where we end up better this has been embodied in the few but incredibly inspiring space entrepreneurs that exist right now. Building better rockets, leading the technology we need to colonize space and interplanetary bodies is the mission right now with the space on tutorial program. Trust really many of those technology will be used to do things like building incredibly powerful and ubiquitous artificial intelligence systems that will completely change life on earth it will help us single area in a much more rapid rate any less think is possible. To me that is the goal. Those are the stars painted in the sky. I love that there are not simple to do but they are simple to state. Because we start talking about ion thrusters and drones in all these things you can lose sight of the facts that what we're trying to do a very simple thing which is get from here to there and make their answer better. As I think that is a really question.

I agree and I think that overall it's also affecting culture in a very big way. Some comments were made on how collaboration needs to happen and bring in different

perspectives to teams. For example this lesson learned in the corporate space and was happening in different companies where we see the case where Ford motors they started sending a couple hundred of their employees in the design from an research from to a local maker space and they were actually those those specific teams were actually able to double their output in terms of patents they were releasing. Things like that show the potential at different levels and also in the corporate sector and how the space is going to be influenced culture in actual cities to really empower people to build and really have an idea to come forward with it.

For me its exploration. It's a journey thing I echo the chats going on is about to that ride and to create something. We don't quite know who you will encounter for where it will be but I think part of it is just that kind of letting go of that whole control thing and see where it goes. The cheesy line that I always say to people's wet imagination take you to places that you never imagined. Let curiosity take you places you never imagined. I think it certainly is what I am going to let happen just curiosity take me to places that I have never imagined and I want to be surprised. The goal is going to be I want to surprise.

I think short-term some of the things that we need our infrastructure support for getting into space. Ground networks are pretty lacking right now in terms of if you launch a cube satellite or regular satellite service providers to get into orbit. Cases is coming online. Nano racks. The ability to actually start getting hardware into space actually have the interaction with space and the ability to get experiments on orbit. Those are things that are really coming. There's actually a high school old Christian Valley high school. They have had over 20 projects flown on the ISS these are all funded by the high school and the actually got the experiment's back. It's pretty amazing and they've obviously perfected a pathway on doing this. That pathway needs to get into the maker community. Some of the experience that they did which were very interesting is they did one that was how does concrete to her in space? That has long reaching implications 0G and vacuum. Amazing experiments. His work conceived of high school kids and assisted with the staff and they were flown and actually returned experiment this type of pathway getting into the maker community to do thing like qualifying components, establishing the networks to do the things that we really want to do to get that initial foothold into space. Those are immediate things. Many of them to tie into grand challenges either the current asteroid one or others that are coming up.

Other thoughts on that? Where is this all headed? We've got about 10 more minutes to IC Alex wanting to comment?

I was going to say that one of the ways I see this headed is not just in regards to space but with regard to makers. If we can make the difference in the actual grand challenge we can make a difference in space. That can act as they showcase. So all other areas that makers can make a difference in. The thing itself is as we discussed a very old phenomenon. But making in the public consciousness it's a reuse of the maker movement. It new and weird thing. You can't just go to the average Joe on the street and tell them you are a maker. They don't get it unfamiliar scary. Being able to group ourselves in space will get the

name out there and get the concept into the consciousness and the Flossie and conceptual bears of people have makers can be a bit informal and not follow the rules so much and that is scary for academia industry and government. And of course the proof is out. But that is the biggest thing.

As we are closing in on the top of the hour and the unfortunate and of our hopefully beginning conversation, I invite folks again to play on the wiki and keep sharing ideas. I'm wondering from the group in terms of what you have heard or shared, what you still think might be a good next step how do we either keep this conversation going or move on from here? As I talked about yesterday in the transition from your one to your two in the grand challenge we are now looking to make and do. We've done a little bit of testing here and there and had a lot of conversations. How do we look to create some tangible next steps? For the grand challenge in particular but the maker community and NASA overall?

I think one of the most interesting programs have had a chance to see is what Alex is doing bit. What they have done my ties is not the right word but they have made this idea that we have some role to play in the coming generation of space technology as individuals. I have made that incredibly clear and that has not been clear at all to most people. Even to people who are tangentially involved in this community. It is still as big lofty thing to go to space we think about to experiment in space and space gambit is said is now it's not. The thoughts that you have in your head are not only brilliant but they are because there are so few people doing it. Space is something that belongs to institutional players and as a consequence a small number of ideas have generated. We've not hit scale yet. Supporting organizations like that and supporting organizations like space gambit or initiatives like the X prize or one of the most important things we can do because it starts a public conversation. Or the related art a less private conversation about what is possible. Everyone loves face and is excited by space mostly apolitical right now. If we can take advantage of this opportunity to have as many of these discussions as possible it's going to make the biggest difference because we need public support. We need people to get wide-eyed about this I think that is really important. That's what I think the next will be his finding as many space gambit's and hacker spaces as we can possibly find and having them be a liaison to the people.

There's a really great idea from 60s NASA program the notion of an atmospheric skimmer. The idea was a satellite going very low orbit that would be able to dip down a little bit and take anything that was booted up into the troposphere. In an taken into orbit. I guess what space Is doing in a way is like getting NASA team and taken it to the next level. Think you're right having more mechanisms in place to help manage the transition is usually the other notes that I made as many as I like the idea of pathways and he mentioned this notion that there defined pathways to learn to do in order to do better. And so I think there's a process of certification we can do to help teams get to make progress. Other note that I made his notion of a design pattern 10 years ago 13 years ago with the Internet the patterns didn't exist but now we know them. But what is the equivalent to the ownership and can we share those design patterns so essentially we are fast tracking work that is done? I think lastly just getting creating more platforms take for me the big theme

of today's talk. It platforms for collaboration we need to seed the work we're doing and create platforms that allow good energy to follow I think that is the role of NASA is to provide that platform and provide the pathways also Leslie provided the atmospheric skimmer to pull us up into orbit.

In the above important points that is really resonated with me is the fact that everyone is fascinated I but there is still this all went about take about space that is so true and it applies to even myself. Huge amount of fascination but also 500 years ago there was one of those kind of people standing on the shores of the oceans looking across and thank I want to get across this it's too big. But someone had to point them toward saying hate you can help us there's already about going out to maybe you can jump on. Or maybe you can just stare at the scars and chart out some stars for us that will help with people getting their. Someone has to break that down into a little bit of tangible options that all of us can jump into and contribute. Otherwise we are taking advantage of the inherent fascination that all of us have. There's no arguing that all of us are fascinated. We'll get stuck at that stage were standing on the beach looking across and saying a well.

I love that. That's beautiful.

That was an interesting feeling that I had when they were talking.

One possibility also the first robotics efforts when you compete in that they give you a basic kit is up to you to innovate. One of the things would be to come up with kids some of the kids could be software. They could be hardware. The hardware kits it could have things in it like regolith and what you would expect to encounter or is it a telescope? We want to improve how do you track asteroids from the ground? This is a basic kind of telescope that you would need. Can you develop motion control and here is a CCD imager. What type of software can you do that would do a time sequence that we could then it there is a core that people can wrap their arms around it's kind of like saying we want you to improve the automobile and go make one. But if instead someone gives you a chassis and a motor and you are there like yes I am going to do the turbo intercooler to make this engine run faster. Again even going back to the Goddard would ever get the opportunity to look at his actual first rockets he is actually chided for being a terrible welder. Everything was braced because he cannot do high temperature welding. It led to a lot of curly failures in his rockets.

If he had a welder at his disposal he probably could've done a lot more initially.

That's a great story. This rate is repeated a number of different ways as well and I think we need to celebrate those stories heard the story about the Indian space program and actually went to the uninhabited island was where they at the initial launch pad. The only way to get there rocket there was on the back of the bicycle he would build a rocket and truck to the back of a bicycle and bicycle all away to the launchpad. There is no launch vehicle there. It's easy to look at the images and take a bicycle?

Of crazy Danish guys building a rocket. They want to put a one-man capsule on it. They were using bits of hairdryers think to help cool the engine down or something. Very [Inaudible - static] I've got to go now.

It was great speaking to all. I will see who again.

If you want to follow me on twitter I will put that into the chat. It will be a good way to indicate. Smack May the force be with you.

I even quit to dignify that with a response.

We are a little bit past time. Really exciting conversation. Folks tuned in and thank you for participating as well. Tune in to the wiki. This is again another path another step on our path were going to take a slight break about half an hour and then come back and have the next generation engagement conversation to our panelists and viewers. Take you so much for taking the time today. They really awesome conversation thank you so much.

Thank you.

Goodbye.

[Event Concluded]